REMARKS

This paper is filed in response to the Office action mailed Nov. 25, 2002. Of pending claim 23-43, the Office action rejects claims 23-25 and 29-43 and objects to claims 26-28. With this paper no changes are made to the application, and so claims 23-43 are still pending.

Claim rejections under 35 USC §112, first paragraph

At paragraph 2 of the Office action, claims 23, 24, and 43 are rejected under 35 USC §112, first paragraph, in that "claims 23 and 24 [and also claim 43] show a Si/SiGe/Si bipolar device where C is provided in any of the base, emitter or collector up to a concentration of 10^{21} cm^{-3} and the lattice change is less than $5x10^{-3}$," but according to the Office action, "if C is added to Si with a concentration at the upper limit the lattice will change by more than the claimed amount and thus the claimed range is not enabled."

Based on a telephone interview with the Examiner on April 24, 2003, applicant interprets the rejections under 35 USC §112, first paragraph, as based on a reading of the rejected claims according to which the Examiner concludes that a carbon concentration at the claimed upper limit of $10^{21}cm^{-3}$ will introduce a relative change in the lattice constant of larger than 0.005, i.e. the added carbon will unavoidably cause a strain of more than one half of a percent. The Examiner indicated during the telephone conversation that it is the Examiner's belief that since the lattice constants of Si and Ge differ from that for C by "about 40%," it is not possible to add C in the concentration claimed and change the relative lattice

constant by less than one half of a percent, i.e. to create a strain of less than only .005.

Applicant respectfully points out that firstly, one cannot infer the strain caused by adding C based on comparing lattice constants since in a crystal even with C added according to the claimed upper limit, C is present as only one atom in fifty ($1x10^{21}$ C atoms per cc vs. $5x10^{22}$ Si or Ge atoms per cc, which is an approximate concentration of Si or Ge in a Si or Ge crystal at room temperature), i.e. only 2% of the atoms are C atoms, and so the resulting crystal is not necessarily at all similar to a C crystal. Also, as a matter of fact, as is explained below in the discussion of the Applied Physics Letters note by Osten *et al*, it is indeed possible to add C atoms as in the upper limit recited in the rejected claims and yet cause a strain (change in lattice) of less than one half of a percent.

Secondly, the rejected claims recite incorporating carbon in at least one of said collector, base, and emitter layers in a concentration between 10^{18} cm^{-3} and 10^{21} cm^{-3}, "so as to (i.e. by controlling process parameters) cause a change in the lattice of less than $5x10^{-3}$." In other words, the claim recites that C is added in such a way--i.e. by controlling the conditions under which the C is added--that the strain is less than one half of a percent. To put it another way, the additional strain is not claimed to be a logical consequence of the carbon concentration, but is instead a further limitation; i.e. the claims recite a transistor (or a method for creating a transistor) wherein (as a first limitation) carbon is incorporated in at least one of the collector, base, or emitter layers in a concentration between 10^{18} cm^{-3} and 10^{21} cm^{-3}, so as to (in

such a way as to, i.e. as a second limitation) cause a change in the lattice of less than $5x10^{-3}$. Both limitations of the rejected claims are met by transistors (or methods for making same) by adjusting process parameters (such as temperature and growth rate) so as to control the concentration of carbon on lattice sites. In a silicon or silicon-germanium lattice, a given carbon concentration by itself does not impose a predetermined concentration-dependent strain value as the Office action suggests. Only substitutional carbon--i.e. carbon on lattice sites--influences the strain and prevents out-diffusion of Boron, while carbon incorporated on interstitial sites has no influence. This has been shown by comparative X-ray and SIMS Measurements on $Si_{1-y}C_y$ layers in a letter entitled *Influence of interstitial carbon defects on electron transport in strained $Si_{1-y}C_y$ layers*, published by H.J. Osten *et al* in Applied Physics Letters, Vol. 76, p. 200-202, copy enclosed. In this paper, table 1 shows comparative X-ray diffraction and SIMS (Secondary Ion Mass Spectroscopy) results for four different $Si_{1-y}C_y$ layers on silicon. In the third column of table 1, the concentration of substitutional Carbon (C_{subst}), as calculated from the lattice distortion seen in X-ray diffraction measurements, is compared to the total Carbon concentration (C_{total}), as determined from SIMS measurements. A comparison of the values in the third column for samples A and D shows that the total concentration of Carbon varies by 50% while the concentration of Carbon on lattice sites is constant. The additionally incorporated Carbon must, therefore, be incorporated on interstitial sites without influencing the lattice distortion. Only Carbon on lattice sites changes the lattice. Therefore, carbon concentration

by itself, even at a concentration of 10^{21} per cc, does not allow deducing a change of strain introduced by carbon. (See col. 2, last paragraph, of the Osten *et al* article in which it is explained that the interstitial carbon concentration is *tuned* by using different growth temperatures and overall growth rates.)

Applicant therefore respectfully submits that the addition of C even at the upper limit of the claimed range will not necessarily cause of change in the strain/ lattice (constant) of more than one half percent, and so requests that the rejections of claims 23, 24, and 43 under 353 USC §112, first paragraph, be reconsidered and withdrawn.

Claim rejections under 35 USC §103

At paragraph 4 of the Office action, claims 25, 29-34, 40 and 41 are rejected under 35 USC §103 as being unpatentable over Lanzerotti *et al*, *Si/$Si_{1-x-y}Ge_xC_y$/Si Heterojunction Bipolar Transistors*, IEEE, hereinafter Lanzerotti *et al* (IEEE) in view of Lanzerotti *et al*, *Suppression of Boron Outdiffusion in SiGe HBTs by Carbon Incorporation*, IEDM, hereinafter Lanzerotti *et al* (IEDM).

Claims 29-34 and 40-41 all depend from claim 25.

With respect to claims 25 and 29, Lanzerotti *et al* (IEDM), on p. 249, first paragraph of the introduction, discuss introducing a high boron doping level into the base for achieving a low base sheet resistance. They do not suggest omitting spacer-layers on either side of the base layer so as to provide a transistor as recited in claim 25, i.e. one in which a doped silicon-germanium base layer is disposed between an emitter layer and a collector layer, the base layer being immediately adjacent to the emitter layer

on one side and to the collector layer on the other side. To the contrary, they consider spacer-layers necessary to "accommodate any boron diffusion during the emitter growth." (See p. 249, right column, first paragraph, lines 4 to 7). Later on, they come to the conclusion that "the carbon … must be separated from the p-n junctions by doped SiGe spacer-layers to prevent high I_B." Thus, Lanzerotti *et al* (IEDM) teach that spacer-layers must *not* be omitted. Therefore, the person skilled in the art would *not* have considered it obvious to omit spacer-layers because of an increase of the base current involved with this measure. A high base current, however, is indicative of a high defect level preventing good high-frequency operation of the hetero bipolar transistor.

Further in respect to claims 25 and 29, in rejecting these claims the Examiner concedes that Lanzerotti *et al* (IEEE) show undoped spacers made of SiGe on either side of the doped base layer "to prevent diffusion of the dopant into the emitter or collector," and so concedes that the base according to Lanzerotti *et al* (IEEE) is not (and should not be) in direct contact with the emitter and collector as claimed. Neverhtheless, the Examiner relies on the introductory section of Lanzerotti *et al* (IEDM), asserting that the introduction explains that it is "necessary to reduce the base resistance … and that the addition of C reduces the diffusion of the B dopant" (so that one would presumably not want undoped regions, such as in the spacers). To justify combining Lanzerotti *et al* (IEEE) with Lanzerotti *et al* (IEDM), the Examiner states that it would be obvious "to omit the undoped spacer layers to reduce the series resistance" (which would therefore result in an

arrangement as in the claimed invention). Applicant respectfully submits that combining references based on such a justification is improper hindsight reconstruction of the claimed invention. The first, main reference, Lanzerotti *et al* (IEEE), teaches a reason for using undoped spacers; there is no teaching in the second reference (or the first reference) that the teaching in the first reference should be ignored. Applicant respectfully submits that the only real "motivation" for making the combination made in the Office actin is to arrive at the claimed invention, which is hindsight reconstruction, and is improper per the MPEP at 706.02(j), which explains that: to combine references, the Examiner must establish a *prima facie* case of obviousness, which requires first, that there be "some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings" (and second, that "there must be a reasonable expectation of success," and third, that the combination made in the Office "teach or suggest all the claim limitations).

For the foregoing reasons, applicant respectfully requests that the rejection under 35 USC §103 of claims 25 and 29 be reconsidered and withdrawn.

With respect to claims 30-34 and 40 and 41, these claims all depend from claim 25 and so are believed allowable for the reasons given above in respect to claim 25.

Therefore, applicant respectfully requests that the rejections under 35 USC §103 of claims 30-34 and 40 and 41 also be reconsidered and withdrawn.

At paragraph 12 of the Office action, claims 35-37 are rejected under 35 USC §103 as being unpatentable over Lanzerotti *et al* (IEEE) in view of Lanzerotti *et al* (IEDM) and further in view of Sato *et al* (U.S. Pat. No. 5,323,032).

In rejecting claim 37, which recites that concentration of germanium in the base layer has a rectangular profile, the Office action states that in *Sato et al* the concentration profile of germanium in the base layer is flat topped. However, *Sato et al* shows that the concentration increases from 0 to 10% between 300 nm and 350 nm, and that the resulting concentration profile is therefore not rectangular, as in claim 37.

In addition, claims 35-37 all depend from claim 25, which for the reasons given above is believed allowable.

Accordingly, applicant respectfully requests that the rejection under 35 USC §103 of claims 35-37 be reconsidered and withdrawn.

At paragraph 15 of the Office action, claim 38 is rejected under 35 USC §103 as being unpatentable over Lanzerotti *et al* (IEEE) in view of Lanzerotti *et al* (IEDM) and further in view of Crabbe *et al* (U.S. Patent No. 5,352,912).

In rejecting claim 38, the Examiner states that in Crabbe *et al* the concentration profile of germanium in the base layer is triangular. However, Crabbe *et al* discloses that the germanium concentration increases from 5% to 23% in the base region and so is one that increases linearly with

distance into the base (and the concentration then decreases gradually from 23% to 0%, but in the collector region).

In addition, claim 38 depends from claim 25, which for the reasons given above is believed allowable.

Accordingly, applicant respectfully requests that the rejection under 35 USC §103 of claim 38 be reconsidered and withdrawn.

At paragraph 17 of the Office action, claim 39 is rejected under 35 USC §103 as being unpatentable over Lanzerotti *et al* (IEEE) in view of Lanzerotti *et al* (IEDM) and further in view of Sato *et al* and Crabbe *et al*.

In rejecting claim 39, the Office action states that the combination of the flat-top concentration profile in *Sato* and the triangular concentration profile in Crabbe *et al* would yield a trapezoidal shape, and that based on this observation alone, "it would have been obvious to use a trapezoidal distribution." Applicant respectfully submits that first, as mentioned above, Crabbe *et al* does not show a triangular germanium profile in the base, and second, the combination made here, even if it were to provide all of the elements of the claimed invention, is pure hindsight construction, and is not proper per MPEP 706.02(j).

In addition, claim 39 depends from claim 25, which for the reasons given above is believed allowable.

Accordingly, applicant respectfully requests that the rejection under 35 USC §103 of claim 39 be reconsidered and withdrawn.

At paragraph 19 of the Office action, claim 42 is rejected under 35 USC §103 as being unpatentable over

Lanzerotti *et al* (IEEE) in view of Lanzerotti *et al* (IEDM) and further in view of Li *et al* (U.S. Patent No. 5,516,708).

Claim 42 depends from claim 25, which for the reasons given. Accordingly, applicant respectfully requests that the rejection under 35 USC §103 of claim 42 be reconsidered and withdrawn.

Conclusion

For all the foregoing reasons it is believed that claims 23-43 are in condition for allowance and their passage to issue is earnestly solicited.

Respectfully submitted,

Dated: April 25, 2003

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